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Chinook Salmon Escapement in the Gulkana River, 2003-2004

by

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Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)	
centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General	
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)	
fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics	
all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

From 28 May to mid-August of 2003 and 2004 escapement of Chinook salmon *Oncorhynchus tshawytscha* in a portion of the Gulkana River was estimated using counting tower techniques. In 2003 the estimate past the tower was 4,890 (SE=270), and in 2004 the estimate was 4,734 Chinook salmon (SE=302). Conditions were suitable for counting during >99% of the planned counting periods in 2003 and >98% in 2004. Data from an ongoing Copper River drainage Chinook salmon radiotelemetry project were utilized both years to estimate the escapement for the entire Gulkana River by expanding the tower estimate by the proportion of radio-tagged Chinook salmon escaping in the Gulkana River that migrated past the tower. Total escapement was estimated to be 5,705 (SE=718) Chinook salmon in 2003 and 9,468 (SE=1,667) Chinook salmon in 2004. Estimated proportions migrating past the tower were 0.86 (SE=0.10) in 2003 and 0.50 (SE=0.08) in 2004. During the same counting periods, sockeye salmon *Oncorhynchus nerka* passage was also recorded. These counts represented only a portion of the run because the sockeye salmon run typically continues well beyond, that of the Chinook salmon run. The escapement of sockeye salmon upstream of the tower site during the active count period for 2003 was estimated at 19,656 (SE=800), and for 2004 was estimated at 15,247 (SE=633).

Key words: Chinook salmon, *Oncorhynchus tshawytscha,* sockeye salmon, *Oncorhynchus nerka*, Copper River, Gulkana River, counting tower, radiotelemetry, spawning escapement.

INTRODUCTION

The Copper River drainage is one of Alaska's largest river systems, encompassing approximately 61,440 square kilometers, and supports important sport, commercial, personal use, and subsistence Chinook salmon *Oncorhynchus tshawytscha* fisheries. Returning Chinook salmon begin crossing the Copper River Delta and enter the Copper River in early May. While peak migration into the river is generally from mid-May to mid-June, smaller numbers of Chinook salmon continue to enter the Copper River through August. The commercial, personal use, and subsistence fisheries are prosecuted across the span of the run and therefore harvest occurs on multiple spawning stocks. The sport fishery occurs almost exclusively in large tributary rivers and targets specific spawning stocks.

Copper River Chinook salmon are managed under four management plans[1] with the primary plan being the *Copper River King Salmon Management Plan* (5 AAC 24.361, 2006). This plan guides management of the commercial and sport fisheries and mandates the department to manage these fisheries to achieve a drainage-wide sustainable escapement goal of 24,000 or more Chinook salmon. Inriver abundance is measured annually with a mainstem mark-recapture study in the lower river, and inriver harvest is subtracted to estimate drainage-wide escapement (Evenson and Wuttig 2000; Wuttig and Evenson 2001; Savereide and Evenson 2002; Savereide 2003-2005; Smith et al. 2005).

While the Copper River salmon management plans and mainstem monitoring programs address the Copper River stock as a whole, little information is available regarding stock-specific escapements or exploitation rates, and there are no established escapement goals for any of the Copper River tributaries. The Gulkana River is a tributary that supports one of the largest Chinook salmon recreational fisheries in the Copper River drainage (Taube 2002). Since 1977 both annual effort and annual harvest have increased substantially (Jennings et al. 2004; Taube 2002). The Gulkana River drainage average annual Chinook salmon sport harvest from 1977 to 1989 was 1,927 fish, increasing to an average 3,394 fish for 1990 through 1999, with 1996 and

[1] The four management plans that guide management of Copper River Chinook salmon are: *Copper River Subsistence Fisheries Management Plans* (5 AAC 01.647, 1993), *Copper River District Salmon Management Plan* (5 AAC 24.360, 2006), *Copper River King Salmon Management Plan* (5 AAC 24.361, 2006), and *Copper River Personal Use Dip Net Salmon Fishery Management Plan* (5 AAC 77.591, 2003).

1998 reporting annual harvests over 5,000 fish (Taube 2002). In addition to direct harvest from the inriver sport fishery, the Gulkana River Chinook salmon stock is subject to harvest in a series of other fisheries that target a mixture of Copper River stocks; specifically, the commercial gillnet fisheries of the Copper River District, and the subsistence and personal use fisheries of the Copper River and Upper Copper River Districts. Similar to the Gulkana River sport fishery harvest, these mixed-stock fisheries have also shown an overall trend of increased harvest over the past 10 years (Ashe et al. 2005; Taube 2002).

In 2002 a multi-year cooperative project was initiated between the Alaska Department of Fish and Game (ADFG) and the Bureau of Land Management (BLM) to establish a Chinook salmon counting tower on the Gulkana River to monitor escapement. The Gulkana River was selected because this stock makes up a large portion of the total Copper River drainage escapement, it supports an intensive sport fishery, access is relatively good, and the upper reaches are clear water. The goal of this project was to collect inseason information on escapement of Chinook salmon in the Gulkana River to aid in management of the sport fishery, and to ultimately establish an escapement goal for this stock.

OBJECTIVES

The objectives of this project were to:

1. estimate the escapement of Chinook salmon upstream of an established tower site on the mainstem Gulkana River, using tower counting techniques, such that the estimate was within 15% of the actual value 95% of the time;
2. estimate the proportion of Chinook salmon escaping in the Gulkana River that migrate upstream of the tower site, using radio-telemetry tracking techniques, such that the estimated proportion was within 15 percentage points of the true proportion 90% of the time; and,
3. estimate the escapement of Chinook salmon in the Gulkana River such that the estimate was within 25% of the true estimate 90% of the time.

In addition to the above objectives, concurrent project tasks were:

1. describe inriver run timing data for Chinook and sockeye salmon in the Gulkana River; and,
2. enumerate sockeye salmon passage at the tower site during the period of tower operation.

METHODS

STUDY AREA

The Gulkana River originates in the Alaska Range and its watershed drains approximately 5,543 square kilometers in southcentral Alaska. From its headwaters upstream of Summit Lake, the Gulkana River flows for approximately 161 km south to its confluence with the Copper River. The mainstem river is fed by the East, Middle, and West forks (Figure 1). The Gulkana supports recreational fisheries for sockeye and Chinook salmon, rainbow trout *O. mykiss*, and Arctic grayling *Thymallus arcticus*, with access primarily by boat. Winding and boulder strewn, it is a primarily clear water, run-off system, although the water level and clarity can fluctuate considerably and quickly in response to weather. Portions of the river system are slow and meandering and others are Class III rapids. In the 130 river kilometers from Paxson Lake to the Copper River, the Gulkana River falls 4.1 kilometers.

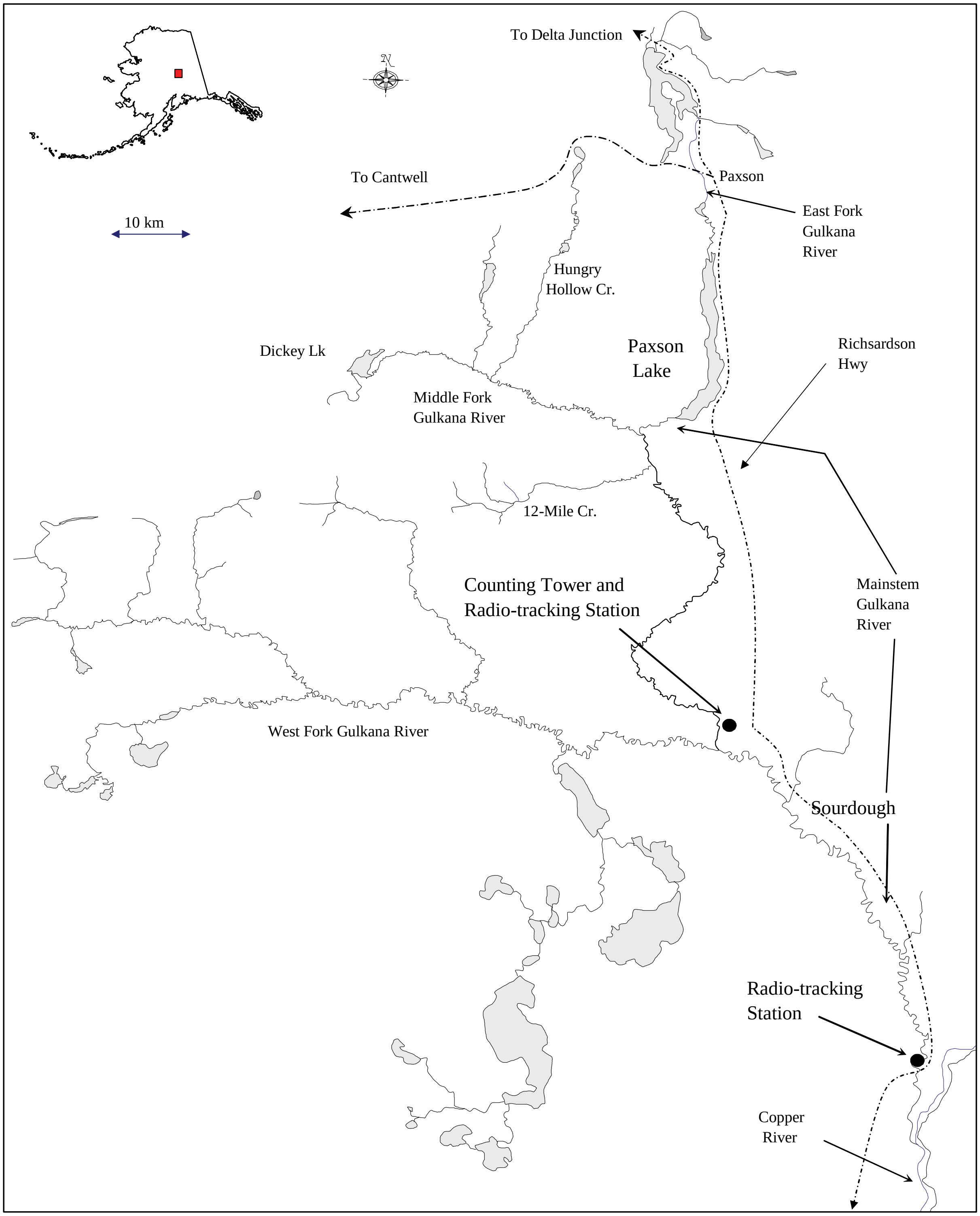

Figure 1.-The Gulkana River drainage and location of the counting tower**.**

The counting tower site is located between Paxson Lake and Sourdough. The section of the Gulkana River upstream of Sourdough has been recognized for its exceptional scenic, recreational, and resource values and has been designated by Congress as a "wild river", part of the National Wild and Scenic Rivers System. The Bureau of Land Management (BLM) manages the lands within this corridor. The counting tower site is approximately 2.5 km upstream of the West Fork confluence, because the West Fork often contributes turbid input and creates poor visibility in the mainstem downstream from its confluence. Stream characteristics used for site selection were river depth, width, and bottom composition. A small island splits the mainstem into two channels at the tower site. This split, with counting towers located on each side of the island, allows for a comprehensive view of the total width (approximately 30 meters per channel) of the mainstem. Maximum depth in both channels ranges from one to 1.5 meters during normal summer flow, and flow is fairly even from bank to bank. The bottom composition is cobble, gravel, and sand/silt, with relatively few boulders. Normal powerboat access to this upper part of the river, including the tower site, is from the public boat launch at Sourdough, which is 19.3 km downstream of the tower site.

ESCAPEMENT OF CHINOOK SALMON PAST THE COUNTING TOWER

Study Design

The number of Chinook salmon returning to an index area in the mainstem Gulkana River was estimated by visually counting fish as they passed by the counting tower station. Results from past aerial survey observations (T. Taube, Sport Fish Biologist, ADF&G, Glennallen; personal communication) and from the first year of this project (Taras and Sarafin 2005) indicated that the majority of spawning in the Gulkana River drainage occurs upstream of this site.

Two three-person crews conducted 10-minute counts for each of two river channels every hour, every day during the Chinook salmon run. Because counts were planned for all hours, daily estimates of abundance were a single-stage direct expansion from the 10-min counting periods. The 10-min counting periods were considered a systematic sample and the abundance estimate was stratified by day. Hourly count data were combined across channels before calculating estimates in order to account for the covariance between channel-specific hourly counts.

Chinook salmon abundance past the tower counting station is equal to escapement only if there is no harvest of pre-spawning salmon above the tower site. While this is not strictly true, the harvest above the tower is thought to be insignificant relative to the number of fish migrating past the tower and the uncertainty associated with the abundance estimate. In 2004, the SWHS was modified to record the harvest of Chinook salmon upstream of the West Fork, allowing the counting tower escapement estimate to be adjusted for harvest. However, a portion of that harvest occurs between the West Fork and the tower site. Therefore, subtracting the SWHS harvest estimate from the tower abundance estimate will lead to underestimating escapement. This negative bias is expected to be small because the <u>total</u> harvest between the West Fork and the tower site is thought to be on the order of 1-3% of the escapement upstream of the tower site (T. Taube, Sport Fish Biologist, ADF&G, Glennallen; personal communication).

Tower Construction and Maintenance

Erecting towers on the island separating the East and West channels provided a short enough distance (approximately 30 meters) to ensure full visibility across the monitored area. Scaffolding towers were installed to provide platforms approximately 4 m above water level from which to view each channel. The platforms were covered on the top and three sides with camouflage-print tarps to prevent silhouetting the observer, and also provide the observer with protection from wind and rain. To make passing fish more visible, and provide a well-defined manner of delineating passage, a continuous band of light-colored vinyl panels, approximately 2-m wide, was anchored to the river bottom. This band of “contrast” or “flash” panels was located at the base of each tower and ran across the width of the adjacent river channel (West or East). There was also a two- to three-meter section of picket weir near the base of each tower platform to ensure no fish were able to pass unseen due to bank characteristics on the island. For both towers the opposite mainland riverbank had a gradual slope and the contrast panels ran smoothly against the substrate and up the bank beyond water level. Debris, silt, gravel, and fish carcasses accumulated regularly on the vinyl panels and weir sections, affecting stream flow and visibility. Clearing of such accumulations was performed, as necessary, at times between scheduled counts. During periods of low ambient light on late summer nights, floodlights were used to illuminate the panels across the entirety of each channel. Exterior-grade floodlights were located above platform height and positioned to provide an even level of illumination across each channel, paralleling the submerged contrast panels. Once the lights were turned on, they remained on between counts to maintain consistent conditions until no longer needed. This was done to reduce any associated effect that lighting changes may have had on salmon passage.

Data Collection

Fish count observations began on 28 May in both years and continued through 18 August in 2003, and 14 August in 2004. During tower construction, which began each year on 23 May, the crew monitored the river to ensure that the beginning of the Chinook salmon run was observed. Had Chinook salmon been observed earlier than anticipated, and before the platforms were erected, counts would have begun from the riverbank. Monitoring was terminated at the end of the run after five continuous days with no daily net upstream passage of Chinook salmon.

Two 10-min counting periods (20 minutes total) were scheduled every hour, for 24 hours each day. The start time for all counts for the West channel began between the top of the hour and 10 minutes past. The 10-min count of the East channel immediately followed the count on the West channel. Numbers of Chinook salmon and sockeye salmon counted during each 10-minute count period were tallied and recorded on count forms at the end of each count period. Separate daily count forms were maintained for each channel. Passage both upstream (+) and downstream (-) was recorded to provide a net upstream passage during each 10-min count, for each channel of the river. Passage was defined as movement across the full 2-m width of the contrast panels. Some fish may have crossed the panels multiple times in both upstream and downstream directions, in particular when spawning occurred in the vicinity of a tower. Observers tallied every upstream and downstream movement, regardless of whether it was suspected, or known, to be the same fish (although this was noted in the comment column on the count form). The only movement not counted, but still noted in the comment field, was that of a carcass floating downstream. Recorded data included numbers of Chinook and sockeye salmon counted in each river channel, date and time of monitoring period, and name of observer. In addition, at the beginning of each hour, water level (relative level on a staff gauge), and water clarity were recorded. The observers evaluated water clarity on a scale of 1 (excellent) to 5 (un-observable), as described in Table 1. Water temperature was recorded at the beginning of each work-shift, at 0600, 1400 and 2200 hours each day. Conditions that might effect the counts (e.g., heavy rain earlier in the day, or strong wind stirring the water surface), or general observations, were recorded in the comments column. The spreadsheets were used for data analysis and for archival recording (Appendix A).

Table 1.–Water clarity classification scheme.

Rank	Description	Fish Viewing	Water Condition
1	Excellent	All passing salmon are observable	Virtually no turbidity or glare, “drinking water” clarity; all routes of passage observable.
2	Good	All passing salmon are observable	Minimal to very low levels of turbidity or glare; all routes of passage observable.
3	Fair	All passing salmon are observable	Low to moderate levels of turbidity or glare, all routes of passage observable.
4	Poor	Some passing salmon may be missed	Moderate to high turbidity or glare; some likely routes of passage obscured.
5	Un-observable	Passing fish are not observable	High level of turbidity or glare; all routes of passage obscured.

Data Analysis

Salmon passage upstream of the tower site and its variance were estimated by day and summed across all days of counting to estimate totals. Daily passage and its variance were estimated under one of three scenarios depending on counting conditions (Table 1):

1. when water clarity was excellent to fair for all scheduled counts during a day, actual counts were expanded to estimate daily passage;
2. when a small portion (defined below) of a day’s counts were conducted under poor or unobservable water clarity, passage during the missed count(s) was estimated using the diurnal migratory pattern and a combination of actual counts and interpolated counts were expanded to estimate daily passage; and
3. when most or all of a day’s counts were conducted under poor or unobservable water clarity, passage for the entire day was interpolated using a moving average estimate of daily passage estimates for successful counting day(s) prior to and after the missing day(s).

For days when all counts were conducted under excellent to fair conditions (scenario 1 above), daily passage, $\hat{N}_d$, was calculated by expanding counts within a shift for day d:

$$\hat{N}_d = Y_d = \frac{M_d}{m_d} \sum_{j=1}^{m_d} y_{dj} \quad . \tag{1}$$

The period sampling is systematic, because the sample (or primary unit) has secondary units taken within every hour in a day (i.e., systematically throughout the day). As provided in Wolter (1985), the variance associated with periods was calculated as:

$$s_d^2 = \frac{1}{2(m_d - 1)} \sum_{j=2}^{m_d} \left(y_{dj} - y_{d(j-1)}\right)^2 \quad . \tag{2}$$

The variance for the expanded daily passage was estimated as:

$$\hat{V}\left(\hat{N}_d\right) = \left(1 - \frac{m_d}{M_d}\right) M_d^2 \frac{s_d^2}{m_d} \quad . \tag{3}$$

where:

d = day;

j = paired 10-min counting period (a paired 10-min counting period consists of the two 10-min counts, one per channel, during a given hour);

y = observed period count (both channels combined);

Y = expanded shift passage;

m = number of paired 10-min counting periods sampled;

M = total number of possible paired 10-min counting periods; and,

D = total number of possible days.

Equations 1 and 3 were taken directly, or modified, from those provided in Cochran (1977). Equation 2 is taken from Wolter (1985).

Equations 1-3 were also used for days having a mixture of reliable and suspect counts (scenario 2 above). However, the number of fish observed, y_{dj},was estimated for periods with suspect counts using known counts for that day, and the diurnal pattern. In all 3 years of this project a distinct diurnal migratory pattern was observed that was consistent between both river channels, and throughout the span of the run. At least 85% of the passage each "day" occurred between 2300 and 1100 hours in each of the 3 years. The pattern was most pronounced in 2002 and 2004, when at least 90% of Chinook salmon were counted between 2300 and 0800 hours. For each year, a "period of peak passage" was defined as the shortest, continuous period of time that accounts for 85% of the seasonal passage of Chinook salmon. To be reliable, expansions based on the diurnal pattern must have at least some counts that were successfully completed during the period of peak passage. The following criteria were established to ensure reliability: if counts were conducted successfully for a portion of the day that represents 25% or more of the expected passage for that day (as defined by the diurnal relationship), and if at least 25% of the periods during peak passage were successfully counted, the channel-specific interpolated count(s) were calculated as the product of the successful counts and the ratio of the expected daily passage not represented to the daily passage that was represented.

$$y_{dc,\mathrm{interp}} = y_{dc,\mathrm{actual}} \times \frac{1 - p_{edp}}{p_{edp}} \tag{4}$$

where:

y = observed period count by channel, interpolated or actual; and,

p_{edp} = proportion of expected daily passage successfully counted.

Analyses of data collected during the first year of the project (2002) indicated that interpolating for undercounts using a diurnal run-timing pattern yielded more accurate estimates of passage than using a direct expansion of the successful counts within 8 hour shifts for that day, as originally proposed (Taras and Sarafin 2005).

The interpolated count was then allocated among missed 10-min counting periods based on the diurnal pattern for the current year. For example, if four hours of counting were missed (four 10-min counts) and the interpolated count for that period was 10 Chinook salmon, those 10 fish would be allocated to each of the four missed 10-min periods in proportions defined by the diurnal pattern. Daily abundance and variances were calculated with equations 1-3 using a combination of actual <u>and</u> interpolated counts. Because simply treating interpolated counts as "known" results in underestimating daily variances, variance estimates were inflated by decreasing m_d, the number of 10-min counting periods sampled each day by the proportion of the expected daily passage successfully counted on that day. For example, if 85% of the expected run was successfully counted on a given day, then $m_{d,adj}$ = 0.85 x m_d =0.85 x 24. For the channel-combined counts the proportion successfully counted was the channel-specific proportions weighted by the proportion of the overall run passing each channel. Although inflating the variance calculations guards against a negative bias, this approach could still lead to unacceptably large biases if days with diurnal interpolations contribute substantially to the overall variance. Therefore, variances are estimated using this approach only as long as interpolations using the diurnal pattern account for a small proportion of the total variance, as was the case in 2002–2004.

If counts were conducted for a portion of the day that represented less than 25% of the expected passage for that day, or if less than 25% of the periods during peak passage were counted successfully (scenario 3 above), the procedure described below for missed days was used to estimate passage for the entire day (i.e., the successful counts conducted that day will not be used for estimation). When counts for *k* consecutive days were suspected biased due to adverse viewing conditions (water clarity = 4–5), the moving average estimate for the missing day *i* was calculated as:

$$\hat{N}_i = \frac{\sum_{j=i-k}^{i+k} I(day\, j \;\; was\, effectively\, sampled)\hat{N}_j}{\sum_{j=i-k}^{i+k} I(day\, j \;\; was\, effectively\, sampled)} \tag{5}$$

where I is an indicator function:

$$I(.) = \begin{cases} 1 \text{ when the condition is true} \\ 0 \text{ otherwise} \end{cases} \quad (6)$$

The interpolated values were used as the point estimates for the daily counts and the daily variation for undercounted days was the maximum variance of the k days before and the k days after the undercounted day i.

Total passage upstream of the tower site for the entire run and its associated variance incorporated all three daily passage estimation scenarios, and was estimated as provided by Cochran (1977):

$$\hat{N}_{PT} = \sum_{d=1}^{D} \hat{N}_d \text{ ; and,} \quad (7)$$

$$\hat{V}\left(\hat{N}_{PT}\right) = \sum_{d=1}^{D} \hat{V}(\hat{N}_d) \quad (8)$$

where:

D = total number of possible days.

TOTAL ESCAPEMENT OF CHINOOK SALMON IN THE GULKANA RIVER AND THE PROPORTION THAT SPAWNED UPSTREAM OF THE COUNTING TOWER

Study Design

The total escapement of Chinook salmon in the Gulkana River, and the proportion of that escapement that migrated upstream of the tower site, were estimated using data collected from radio-tagged Chinook salmon released in the mainstem Copper River in a separate study (Savereide 2004, 2005). In the mainstem Copper River study, approximately 500 Chinook salmon were radio-tagged throughout the run (mid-May to mid-July) each year. Tagging took place at Baird Canyon, in the lower Copper River. All radio-tagged Chinook salmon also received a numbered Floy tag at the base of the dorsal fin as a secondary mark. Distribution of Chinook salmon within the Gulkana River drainage was assessed with ground-based tracking stations, aerial-tracking surveys, boat tracking surveys, and returned tags from the sport fishery.

Radio tags were recorded entering the Gulkana River by a ground-based radio tracking station placed near the mouth of the river. Radio tagged Chinook salmon entering the Gulkana River were carefully tracked to determine if they migrated above counting tower. In addition, the exact fate (i.e., harvested, expelled tag, or spawned) of all fish failing to migrate above the tower was determined. It was assumed that all radio-tagged Chinook salmon migrating past the tower site spawned. Technically, “migrating past the tower” cannot be equated to “spawning above the tower” because some harvest occurs above the counting tower. The number of radio-tagged Chinook salmon migrating above the tower, however, was insufficient to provide an unbiased estimate of the proportion harvested above the tower. This was in large part due to the low level of harvest above the counting tower and it will be shown below that the low level of harvest translated into an insignificant bias in the estimate of escapement.

Sampling Methods

Two ground-based tracking stations were placed on the Gulkana River. One was placed near the Richardson Highway Bridge, and the second at the counting tower (Figure 1). Aerial tracking flights were conducted between late June and late August to survey the entire Gulkana River drainage. Boat tracking surveys were then performed to more precisely locate the tags between the counting tower and the Richardson Highway Bridge and to determine if the tagged fish were dead or alive, or if the tag had been expelled before migrating to a spawning area. It was assumed that all radio-tagged Chinook salmon migrating past the tower site spawned. Technically, "migrating past the tower" cannot be equated to "spawning upstream of the tower" because some harvest occurs in the upstream area. But as previously discussed, the harvest occurring upstream of the counting site was considered to be negligible.

Data Collection

Each of the two radio-tracking stations was comprised of the following integrated components: two marine deep cycle batteries, a solar array, an ATS[2] model 5041 Data Collection Computer (DCC II); an ATS model 4000 receiver, an antenna switching box, housing, and two elevated Yagi antennas. The receiver and DCC II were programmed to scan through the frequencies at 3 s intervals, receiving with both antennae simultaneously, and pausing for 5 s at which time the tag frequency, code, signal strength, date, time, and antenna number were recorded by the data logger for all signals of sufficient strength. Data from each station were downloaded to a laptop computer at least once every 7-10 days with use of PROCOM PLUS software provided by the manufacturer.

During aerial-tracking surveys, all frequencies were loaded into the receiver/scanner prior to each flight. Dwell time on each frequency was 2 s. Flight altitude ranged from 100-300 m above ground. Two antennae, one on each wing strut, were mounted such that the antennae received signals perpendicular to the direction of travel. Flights followed along the course of the river as much as possible. Once a tag was identified, its frequency, code, and location (from a GPS receiver on the aircraft) were recorded.

The fates of those radio-tagged fish identified during aerial-tracking surveys as located between the Richardson Highway Bridge and the counting tower were determined during boat tracking surveys. A small, outboard-powered riverboat idled downstream while scanning for tags. The approximate locations of the radio tags were known from the aerial survey. Once a radio signal from a tagged fish was encountered, attempts were made to locate the fish. This was accomplished by one person holding a receiver (with a variable gain control) and an H-antenna while a second person navigated the boat as close as possible to the tag. When possible, a visual sighting of the tag, either in a live fish (if an external Floy tag was visible), in a carcass, or expelled into the river, was made. If the tag was not sighted, attempts were made to prompt movement of the fish by driving the boat repeatedly over the area where the loudest signal was heard. If the tagged fish was dead, or if the tag was expelled into the river, attempts were made to recover the tag. Long-handled spears were used to retrieve carcasses from the river bottom, and long-handled dipnets were used to recover tags lying on the river bottom. Data were recorded for every radio-tagged fish located during the boat-tracking excursions.

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[2] Advanced Telemetry Systems, Isanti, Minnesota. Use of this company name does not constitute endorsement, but is included for scientific completeness.

Data Analysis

Each radio-tagged fish that entered the Gulkana River was assigned one of five distinct fates (Table 2).

Table 2.–Description of fates of radio-tagged Chinook salmon migrating into the Gulkana River.

	Fate	Description
1	Migrant above tower site.	A radio-tagged fish that migrated past the counting tower and was either logged by the tower site radio-tracking station or located during an aerial survey.
2	Spawner below tower site.	A radio-tagged fish that was located downstream from the counting tower AND was verified from boat tracking as a fish that successfully spawned. Includes radio-tagged fish located in the West Fork during an aerial survey.
3	Harvest below tower site.	A radio-tagged fish harvested in the sport fishery below the counting tower.
4	Expelled tag below tower site.	A radio tag that was located downstream from the counting tower AND was verified from boat tracking as having been expelled. A fish with an expelled tag may also be identified as having been harvested via a returned Floy tag, in which case, it was assigned Fate 3.
5	Natural mortality below tower site.	A radio-tagged fish not located above the counting tower AND that was verified from boat tracking as a fish that died. Evidence of having spawned results in an assignment of Fate 2 rather than Fate 5.

The proportion of Chinook salmon entering the Gulkana River that migrated upstream of the counting tower site and the, and its variance, were estimated as described in Cochran (1977):

$$\hat{p}_{PT} = \frac{n_{PT}}{n_{GR}} \tag{9}$$

$$\hat{V}\left[\hat{p}_{PT}\right] = \frac{\hat{p}_{PT}\left(1-\hat{p}_{PT}\right)}{\left(n_{GR}-1\right)} \tag{10}$$

where:

n_{PT} = the number of radio tagged Chinook salmon that migrated past the counting tower (Table 2, Fate 1); and,

n_{GR} = the number of radio-tagged Chinook salmon that migrated past the counting tower AND the number that entered the Gulkana River that did not expel tags or die prior to spawning below the counting tower (Table 2, Fates 1 and 2).

The number of Chinook salmon escaping into the Gulkana River was estimated by expanding the estimate of abundance from the tower counts, by the estimated proportion of escaping Chinook salmon that migrated past the tower site:

$$\hat{N}_{total} = \frac{\hat{N}_{PT}}{\hat{p}_{PT}} \tag{11}$$

where:

$\hat{N}_{PT}$ = the number of Chinook salmon estimated past the counting tower; and,

$\hat{p}_{PT}$ = the estimated proportion of Chinook salmon escaping in the Gulkana River that migrated past the counting tower.

The variance of the total abundance was estimated using Goodman's (1960) formula for an exact variance of a product:

$$\hat{V}\left[\hat{N}_{total}\right] = \left(\frac{1}{\hat{p}_{PT}}\right)^2 \left(\hat{V}\left[\hat{N}_{PT}\right]\right) + \left(\hat{N}_{PT}\right)^2 \left(\hat{V}\left[\frac{1}{\hat{p}_{PT}}\right]\right) - \left(\hat{V}\left[\frac{1}{\hat{p}_{PT}}\right]\right)\left(\hat{V}\left[\hat{N}_{PT}\right]\right) \qquad (12)$$

where:

$\hat{V}\left[\hat{N}_{PT}\right]$ = variance of the estimate of Chinook salmon passing the counting tower (equation 5), and

$$\hat{V}\left(\frac{1}{\hat{p}_{PT}}\right) \approx \frac{1}{\hat{p}_{PT}^4}\hat{V}\left(\hat{p}_{PT}\right) \qquad (13)$$

by the delta method (Seber 1982).

PARTIAL ESCAPEMENT OF SOCKEYE SALMON ABOVE THE COUNTING TOWER

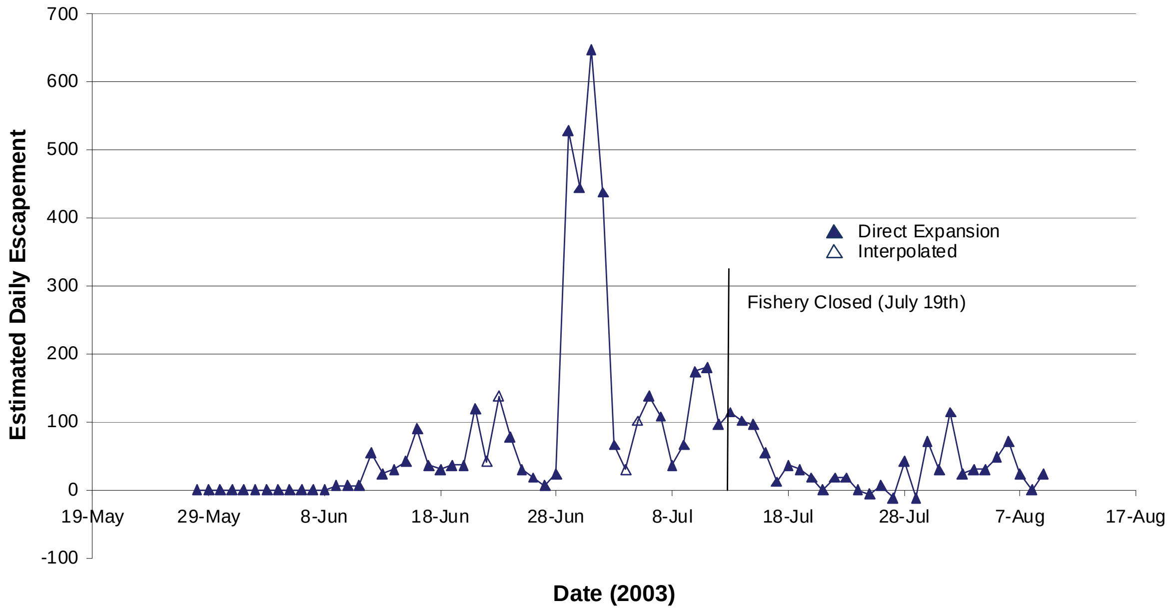
Sockeye salmon that migrated past the tower were also counted and the number of sockeye migrating past the tower during the experiment was estimated. Because the sockeye salmon run was in progress before counting began, and was known to continue well beyond that of the Chinook salmon, the escapement estimate reflects only a portion of the total run. Procedures were identical to those described for estimating the Chinook salmon escapement past the tower.

RESULTS

ESCAPEMENT OF CHINOOK SALMON UPSTREAM OF THE COUNTING TOWER

The Chinook salmon escapement upstream of the tower site for 2003 was estimated at 4,890 fish (SE = 270), and for 2004 estimated at 4,734 (SE = 302). The first Chinook salmon were observed 9 June 2003, and 6 June 2004, and counting continued through 17 August in 2003 and 14 August 2004. For the purpose of estimating escapement the run was considered complete on 9 August in 2003 and 8 August in 2004. In 2003 there was a net upstream raw count of 791 Chinook salmon. In 2004 the net upstream raw count was 777 Chinook salmon. Daily escapement counts are provided in Appendix B and depicted in Figures 2 and 3.

Estimated Chinook Salmon Escapement Past the Gulkana Tower, 2003



Estimated Chinook Salmon Escapement Past the Gulkana Tower, 2004

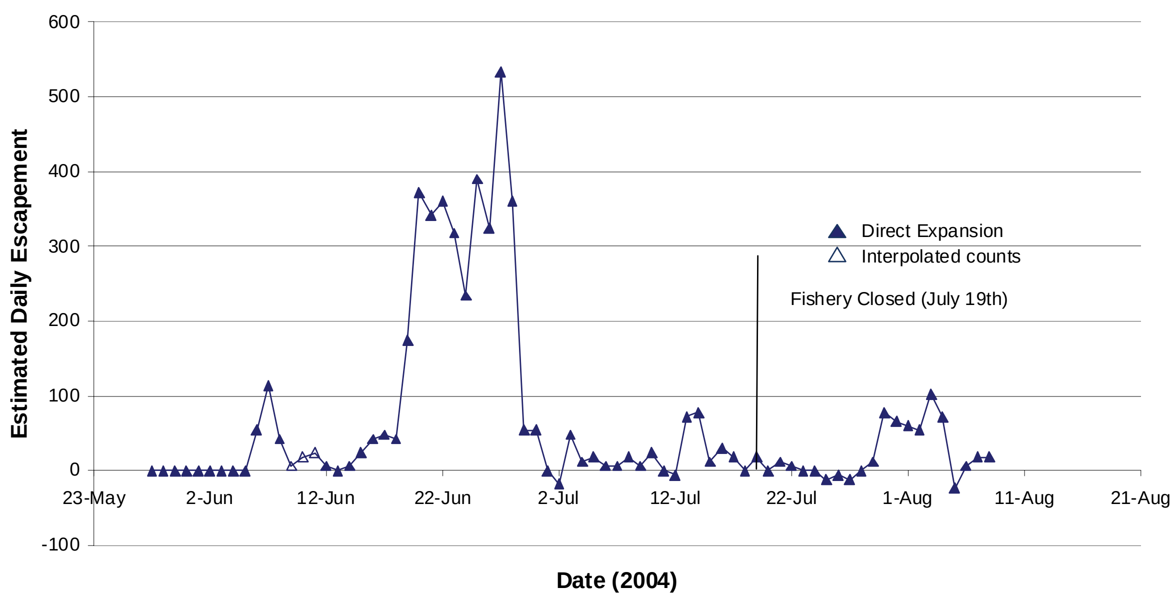
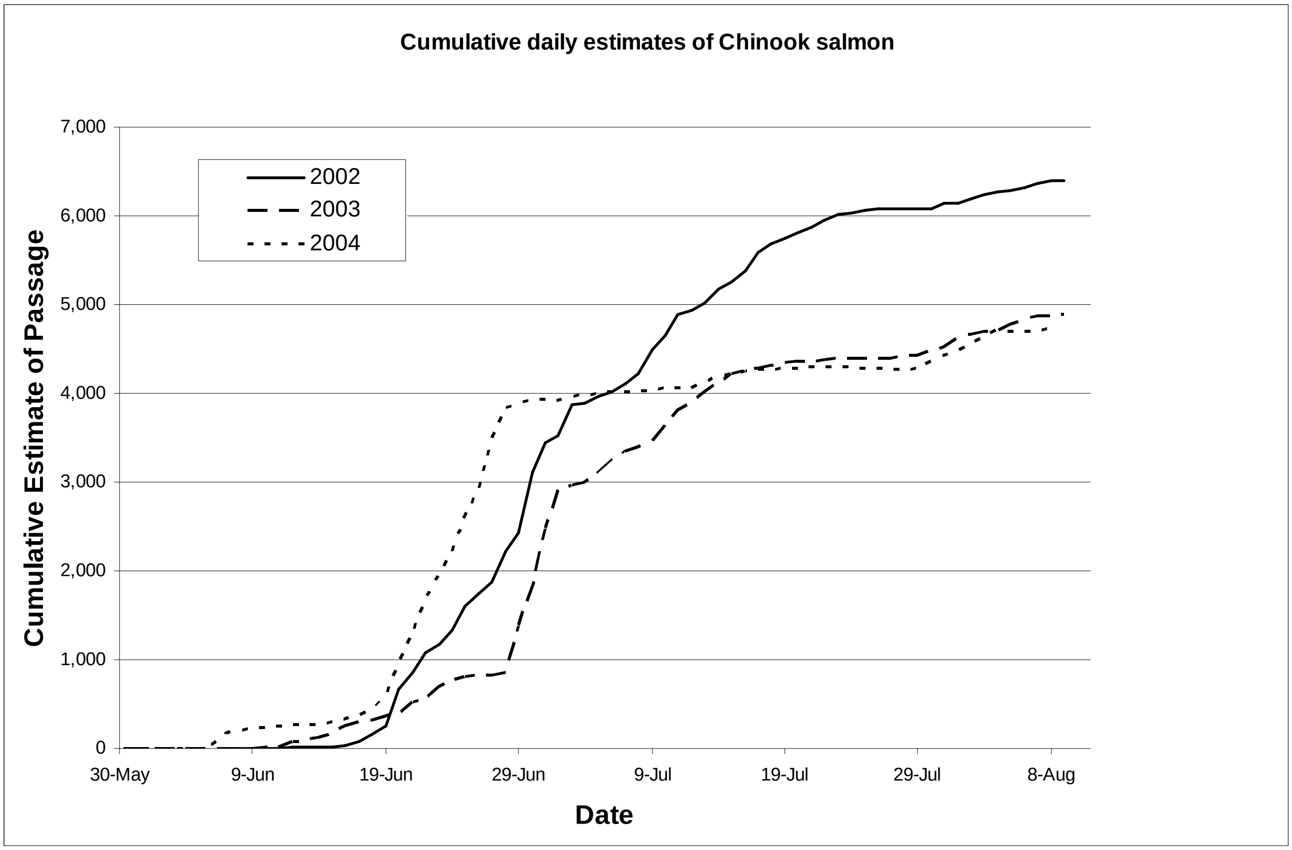


Figure 2.–Estimated daily escapement of Chinook salmon migrating past the Gulkana River counting tower, 2003-2004.



`**Figure 3.–**Cumulative daily estimates of Chinook salmon migrating past the Gulkana River counting tower, 2002-2004.

Less than 1% of the scheduled counting periods in 2003 and < 2% in 2004 were conducted under visibility conditions under which undercounting may have occurred. Analysis of the data, field notes, and discussions with field crew indicated the potential for undercounting corresponded with visibility class 5 and not 4, as indicated in Table 1. The crew began using a value of 4.5 to indicate visibility at which undercounting became an issue. For the purpose of these analyses, 4.5 was equated to a rating of 5. As in 2002, a distinct diurnal migratory pattern was observed that was consistent between both river channels and throughout the span of the run and was used to interpolate for periods of undercounting (Figure 4). However, the final (interpolated) counts were very close to the raw counts for both years due to exceptionally good viewing conditions (Appendix B).

The previously reported estimates of escapement for 2002 (Taras and Sarafin 2005) were revised slightly due to a minor change in estimation methodology. The revised escapement upstream of the counting tower is 6,390 (SE = 340); the previously reported value was 6,355 (SE = 318). The 2002 estimates raw and interpolated counts are provided (Appendix B1).

THE TOTAL ESCAPEMENT OF CHINOOK SALMON IN THE GULKANA RIVER AND THE PROPORTION THAT SPAWNED UPSTREAM OF THE COUNTING TOWER

Total escapement of Chinook salmon in the entire Gulkana River was estimated by expanding the estimates of escapement past the tower by the estimate of the proportion of this escapement that migrated above the counting tower. Estimated total escapement was 5,705 (SE = 718) for

2003, and 9,468 (SE = 1,667) for 2004. The total escapement for 2002 was estimated at 7,911 (SE = 878); this estimate was previously reported as 7,869 (SE = 862; Taras and Sarafin 2005). The proportion of the escapement that migrated above the tower was estimated as 0.86 (SE = 0.10) for 2003, and 0.50 (SE = 0.08) for 2004. The same proportion estimate in 2002 was 0.81 (SE = 0.08). These estimates were determined from the fates of the radio-tagged Chinook salmon (Table 3).

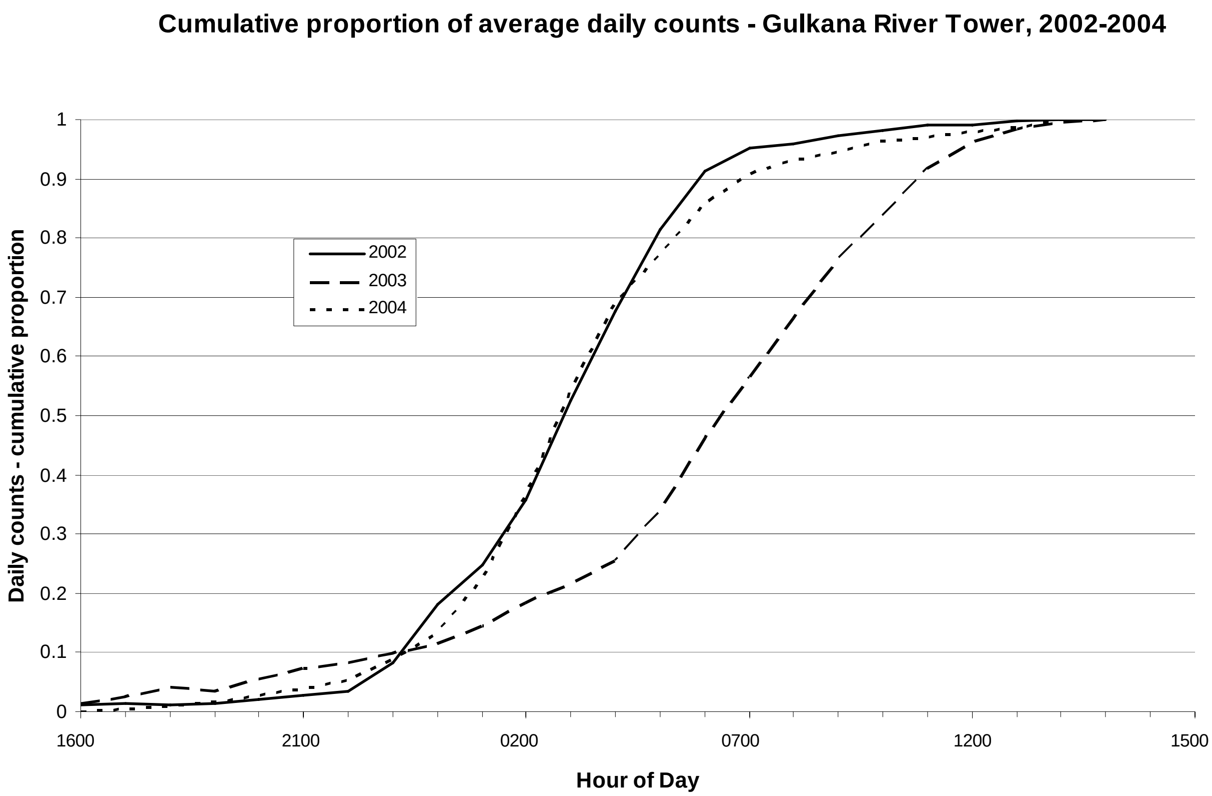


Figure 4.–Diurnal patterns for 2002-2004; the cumulative proportion of average daily counts by hour of day for Chinook salmon migrating past the Gulkana River counting tower.

Table 3.–Fates of radio-tagged Chinook salmon entering the Gulkana River in 2003 and 2004.

Fate	Number of Salmon	
	2003	2004
Migrants into Gulkana River	30	53
Harvested below tower site (Fate 3)a	16	11
Expelled tag below tower site (Fate 4)a	0	4
Natural mortality below tower site (Fate 5)a	0	0
Total Spawners	14	38
Migrants upstream of the tower (Fate 1)	12	19
Spawner downstream of the tower (Fate 2)	2	19

PARTIAL ESCAPEMENT OF SOCKEYE SALMON PAST THE TOWER

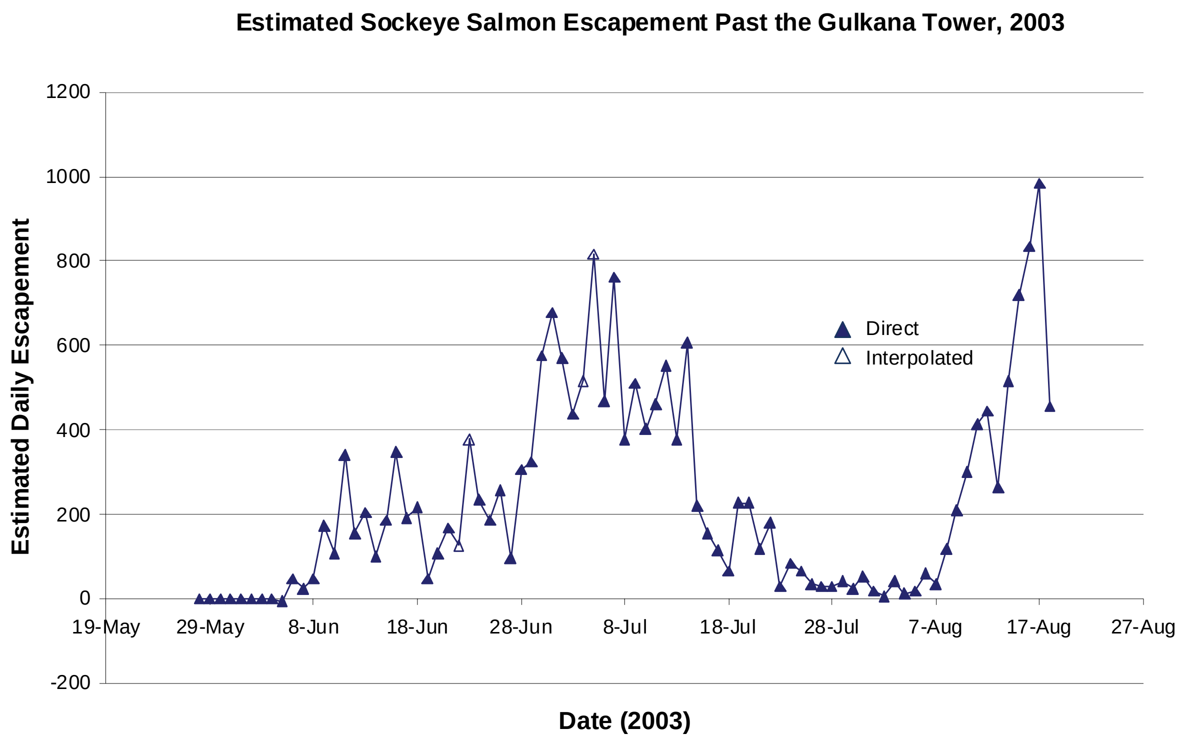
The sockeye salmon escapement upstream of the tower site during 9 June – 17 August 2003 was estimated at 19,656 fish (SE=800). For the period 6 June–14 August 2004 the estimated escapement was 15,247 (SE=633). These estimates include interpolations for poor observation conditions during the counting period, but only a portion of the total sockeye run is accounted for during this period (Figure 5; Appendix C). The estimate of sockeye escapement above the counting tower during the monitoring period in 2002 was 30,062 (SE=1,472), which was previously reported as 30,066 (SE=1,367).

DISCUSSION

A long-term goal of this project is to collect data necessary to establish an escapement goal for Chinook salmon in the Gulkana River. Because the Gulkana River supports an intensive sport fishery, inseason information on run size and an escapement goal are needed to better manage the sport fishery and ensure escapements are adequate to sustain production. The existing Copper River drainage sustainable escapement goal of 24,000 Chinook salmon facilitates management of the mixed stock commercial, subsistence, and personal use fisheries, but does not stipulate any tributary-specific goals. In addition, inriver abundance for the Copper River is assessed with mark-recapture techniques and does not provide inseason information on run strength.

Historically, fishery managers have lacked reliable Chinook salmon escapement data on the Gulkana River. Aerial surveys are conducted to evaluate peak Chinook salmon escapement. However, these surveys are considered to be index counts, not estimates of total escapement. In addition, the accuracy of these aerial index counts may be called into question because of the potentially high likelihood of bias from several factors, including variable weather and river conditions, timing of the survey flights relative to yearly variability in run timing, and consistency of and between specific observers. An ADF&G weir was operated in the Gulkana River, downstream of the West Fork Gulkana River confluence and upstream of Sourdough Campground, in July 1996 (LaFlamme 1997) to generate the only comprehensive estimate of the escapement of Chinook salmon in the Gulkana River. Based on the weir count and a concurrent two-stage access-point creel survey, the inriver return was estimated as 13,840 Chinook salmon, and the spawning escapement was estimated as 11,399 Chinook salmon. The only other inseason information for fishery managers to evaluate run size and escapement is anecdotal reporting from anglers and fishing guides who provide reports of effort, catch, harvest, and river conditions.

Escapement goals are established following guidelines given in the *Policy for the Management of Sustainable Salmon Fisheries* (5 AAC 39.222, 2003) and the *Policy for Statewide Salmon Escapement Goals* (5 AAC 39.223, 2003). These policies define two types of goals that ADF&G can establish: biological escapement goals (BEG) and sustainable escapement goals (SEG). A BEG is a range around the estimated escapement that on average provides for maximum sustained yield. BEGs require a relatively long time series of escapement and total return estimates, which are derived from run reconstruction and development of brood tables. Hence, in addition to escapement estimates, stock-specific estimates of harvest from the mixed stock fisheries (commercial, subsistence, personal use, and sport) are needed to estimate total return of Gulkana River Chinook salmon from a given brood year escapement. Because there is no project underway to estimate stock-specific harvests in the mixed-stock fisheries, and because of difficulties encountered in determining a reliable method to estimate age and sex composition of the Gulkana River escapement (Taras and Sarafin 2005), the data being collected from this study will most likely be used to develop an SEG instead of a BEG. An SEG is a range of escapements indicated by an estimate of escapement or an escapement index that is known to provide for sustained yield over a 5 to 10 year period.



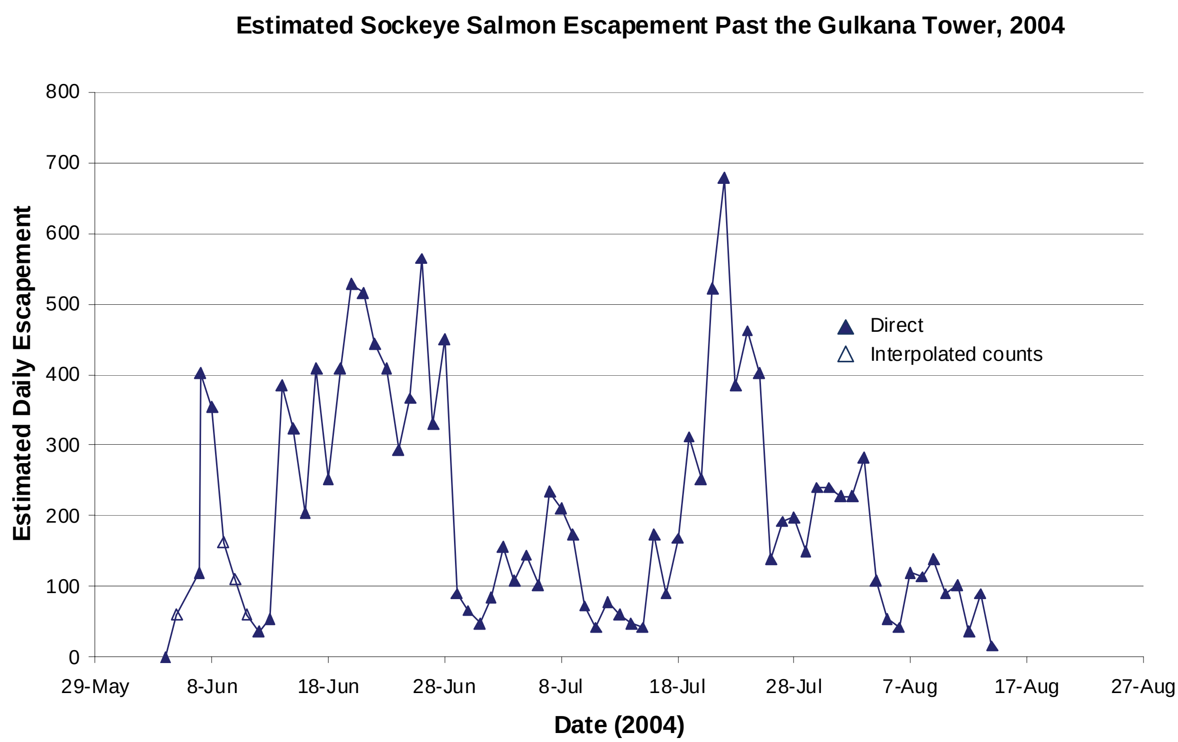


Figure 5.–Estimated daily escapement of sockeye salmon migrating past the Gulkana River counting tower, 2003-2004.

Ideally, an escapement monitoring project should either estimate total escapement for a particular stock, or provide an index of escapement that is consistent over time with respect to the fraction of the escapement that is enumerated and the biological characteristics of the population (e.g., sex and age composition). The concurrent radiotelemetry study allowed for three consecutive estimates of the proportion of the total escapement enumerated by the counting tower. The proportion of escaping Chinook salmon that passed the tower was relatively consistent in 2002 and 2003 (0.81 and 0.86, respectively), but was significantly less (0.50) in 2004, casting some concern over using the tower abundance estimates as a consistent index of escapement and in the development of an SEG. The water level was extremely low in 2004, which may have restricted the upstream movement of Chinook salmon, though this hypothesis has not been tested.

Given the variability observed in the proportion spawning above the tower, a conservative approach should be taken when developing or evaluating an escapement goal. Unless additional information suggests otherwise, it should be assumed that the proportion of the total Gulkana River escapement spawning above the tower is equal to the upper end of the observed estimates (i.e., ~0.85). If, in a given year, the actual proportion is less than this assumed value, then total escapement is underestimated. As described for 2002 data (Taras and Sarafin 2005), the reliability of these proportion estimates were dependent on accurate determination of the fate of radio-tagged fish remaining in the mainstem Gulkana River which were thought to be highly reliable in both 2003 and 2004.

It is unlikely that aerial survey counts will provide a consistent means of assessing the proportion of the escapement above the tower. During 2002 – 2004 aerial survey counts above the tower did not correlate well with escapement past the tower. For example, the estimates of escapement past the tower in 2003 and 2004 were very similar (4,890 and 4,734 salmon, respectively), yet aerial survey counts differed by more that a factor of 2 (982 and 2,014 salmon, respectively).

The estimate for escapement above the counting tower assumed negligible harvest above the tower. During 2002-2003 estimates of harvest from the Statewide Harvest Survey (SWHS) were poorly constrained because harvest was reported for all waters upstream of Sourdough (Figure 1). However, harvest above the tower was thought to be quite low compared with escapement (Taras and Sarafin 2005). In 2004, the SWHS was modified to estimate harvest between the West Fork and Paxson Lake. Estimated harvest above the West Fork in 2004 was zero Chinook salmon. The adjustments to the Statewide Harvest Survey will allow for adjustments to the counting tower estimate in future years if necessary.

Counting operations continued until the net upward movement was zero or less when averaged over five consecutive days. This approach was taken to estimate nearly the entire escapement above the tower and to account for spawning near the tower and the associated post-spawning milling behavior. Milling of Chinook salmon around the tower leads to the possibility of both positive and negative 10 minute counts near the end of run that do not reflect net upstream movement. Obvious carcasses floating downstream were not counted; however, live Chinook salmon crossing the panels moving downstream were tallied and subtracted from those tallied moving upstream. As a result, there was a net negative passage during the last five or more days monitoring (Appendix B). In both 2003 and 2004 the escapement estimates were based on data collected through the date judged to represent maximum upstream passage. After this date, nearly all passage over the panels was attributed to milling salmon.

RECOMMENDATIONS

No major modifications to the design of the study are recommended. However, consideration should be given to initiating a mainstem Gulkana River Chinook salmon radiotelemetry study to continue investigating the proportion of the escapement that spawn above the counting tower.

ACKNOWLEDGEMENTS

Partial funding for this project was provided by the Bureau of Land Management (BLM) and also by the U.S. Fish and Wildlife Service through the Federal Aid in Fish Restoration Act (16 U.S.C. 77-777K) under Projects F-10-18-S-3-1(c) and F-10-19-S-3-1(c). The authors wish to thank the ADF&G field crew: Ron Burr, Austin Mahalkey, Mark Schlenker, Mark Stadtmiller, and Wayne Sutton, and the BLM student technicians Kent Buchanan, Joy Retzlaff, Gus Castro and Blake Delaney who expertly collected data. Thanks go also to Elijah Waters, BLM, whose efforts were paramount to project funding and success.

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APPENDIX A

Appendix A.-Data files[a] for the Chinook salmon escapement in the Gulkana River, 2003 and 2004 project.

Data file	Description
GulkanaTowerRawData_2003.xls	Raw data collected at Gulkana River Counting Tower, 2003.
GulkanaTower03_king.xls.	Data analysis on Chinook salmons counts collected at the Gulkana River Counting Tower, 2003.
GulkanaTower03_king.xls.	Data analysis on Chinook salmons counts collected at the Gulkana River Counting Tower, 2003.
GulkanaTowerRawData_2004.xls	Raw data collected at Gulkana River Counting Tower, 2004.
GulkanaTower04_sockeye.xls.	Data analysis on sockeye salmons counts collected at the Gulkana River Counting Tower, 2004.
GulkanaTower04_sockeye.xls.	Data analysis on sockeye salmons counts collected at the Gulkana River Counting Tower, 2004.

[a] Data files are archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.

APPENDIX B

Appendix B1.–Daily counts, daily expanded estimates and daily estimates that include interpolations for missed counts[a, b] of Chinook salmon at the Gulkana River tower site, 2002. These data are modified from those presented in Taras and Sarafin (2005).

	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
7-Jun	0	0	0	0	0	0	0	0	0	0
8-Jun	0	0	0	0	0	0	0	0	0	0
9-Jun	0	0	0	0	0	0	0	0	0	0
10-Jun	0	0	0	0	0	0	0	0	0	0
11-Jun	0	0	0	0	0	0	0	0	0	0
12-Jun	3	18	18	0	0	0	3	18	18	18
13-Jun	0	0	0	0	0	0	0	0	0	18
14-Jun	0	0	0	0	0	0	0	0	0	18
15-Jun	0	0	0	0	0	0	0	0	0	18
16-Jun	0	0	0	3	18	18	3	18	18	36
17-Jun	0	0	0	8	48	48	8	48	48	84
18-Jun	1	6	6	12	72	72	13	78	78	162
19-Jun	0	0	0	16	96	96	16	96	96	258
20-Jun	3	18	***0***	71	426	***408***	74	444	***408***	***666***
21-Jun	1	6	***2***	5	30	***196***	6	36	***198***	***864***
22-Jun	0	0	***4***	5	30	***214***	5	30	***218***	***1,082***
23-Jun	1	6	6	13	78	***84***	14	84	***90***	***1,172***
24-Jun	1	6	6	25	150	150	26	156	156	***1,328***
25-Jun	2	12	12	45	270	270	47	282	282	***1,610***
26-Jun	1	6	6	21	126	126	22	132	132	***1,742***
27-Jun	0	0	0	21	126	126	21	126	126	***1,868***
28-Jun	1	6	6	57	342	342	58	348	348	***2,216***
29-Jun	3	18	18	32	192	192	35	210	210	***2,426***
30-Jun	38	228	228	75	450	450	113	678	678	***3,104***
1-Jul	5	30	30	52	312	312	57	342	342	***3,446***
2-Jul	0	0	0	14	84	84	14	84	84	***3,530***
3-Jul	3	18	***24***	52	312	312	55	330	***336***	***3,866***
4-Jul	0	0	0	4	24	***30***	4	24	***30***	***3,896***
5-Jul	0	0	***8***	8	48	***72***	8	48	***80***	***3,976***
6-Jul	1	6	***2***	6	36	36	7	42	***38***	***4,014***
7-Jul	0	0	0	15	90	90	15	90	90	***4,104***
8-Jul	1	6	6	19	114	114	20	120	120	***4,224***
9-Jul	4	24	24	42	252	252	46	276	276	***4,500***
10-Jul	11	66	66	15	90	90	26	156	156	***4,656***
11-Jul	10	60	60	28	168	168	38	228	228	***4,884***
12-Jul	0	0	0	9	54	54	9	54	54	***4,938***
13-Jul	0	0	0	13	78	78	13	78	78	***5,016***
14-Jul	2	12	12	24	144	144	26	156	156	***5,172***
15-Jul	3	18	18	10	60	60	13	78	78	***5,250***
16-Jul	0	0	0	22	132	132	22	132	132	***5,382***
17-Jul	4	24	24	30	180	180	34	204	204	***5,586***
18-Jul	1	6	6	15	90	90	16	96	96	***5,682***
19-Jul	4	24	24	7	42	42	11	66	66	***5,748***
20-Jul	3	18	18	8	48	48	11	66	66	***5,814***
21-Jul	2	12	12	9	54	54	11	66	66	***5,880***
22-Jul	3	18	18	8	48	48	11	66	66	***5,946***
23-Jul	2	12	12	9	54	54	11	66	66	***6,012***
24-Jul	2	12	12	0	0	0	2	12	12	***6,024***
25-Jul	2	12	12	5	30	30	7	42	42	***6,066***
26-Jul	1	6	6	0	0	0	1	6	6	***6,072***
27-Jul	3	18	18	-1	-6	-6	2	12	12	***6,084***

-continued-

Appendix B1.–Page 2 of 2.

Day	East Channel Daily Count	East Channel Expanded Count	East Channel Interpolations Included	West Channel Daily Count	West Channel Expanded Count	West Channel Interpolations Included	Total Daily Count	Total Expanded Count	Total Interpolations Included	Season Cumulative Estimate
28-Jul	0	0	0	0	0	0	0	0	0	***6,084***
29-Jul	-1	-6	-6	1	6	6	0	0	0	***6,084***
30-Jul	-3	-18	-18	3	18	18	0	0	0	***6,084***
31-Jul	7	42	42	2	12	12	9	54	54	***6,138***
1-Aug	2	12	12	-1	-6	-6	1	6	6	***6,144***
2-Aug	-1	-6	-6	8	48	48	7	42	42	***6,186***
3-Aug	2	12	12	8	48	48	10	60	60	***6,246***
4-Aug	0	0	0	4	24	24	4	24	24	***6,270***
5-Aug	0	0	0	2	12	12	2	12	12	***6,282***
6-Aug	0	0	0	6	36	36	6	36	36	***6,318***
7-Aug	0	0	0	8	48	48	8	48	48	***6,366***
8-Aug	0	0	0	5	30	30	5	30	30	***6,396***
9-Aug	0	0	0	-1	-6	-7	-1	-6	-6	***6,390***
TOTAL	128	768	760	877	5,262	5,630	1,005	6,030	6,390	***6,390***

[a] Negative values represent downstream passage.

[b] Shading indicates days with interpolated values that are shown in bold italics when different from expanded count.

Appendix B2.–Daily counts, daily expanded estimates and daily estimates that include interpolations for missed counts[a, b] of Chinook salmon at the Gulkana River tower site, 2003.

	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
28-May	0	0	0	0	0	0	0	0	0	0
29-May	0	0	0	0	0	0	0	0	0	0
30-May	0	0	0	0	0	0	0	0	0	0
31-May	0	0	0	0	0	0	0	0	0	0
1-Jun	0	0	0	0	0	0	0	0	0	0
2-Jun	0	0	0	0	0	0	0	0	0	0
3-Jun	0	0	0	0	0	0	0	0	0	0
4-Jun	0	0	0	0	0	0	0	0	0	0
5-Jun	0	0	0	0	0	0	0	0	0	0
6-Jun	0	0	0	0	0	0	0	0	0	0
7-Jun	0	0	0	0	0	0	0	0	0	0
8-Jun	0	0	0	0	0	0	0	0	0	0
9-Jun	0	0	0	1	6	6	1	6	6	6
10-Jun	0	0	0	1	6	6	1	6	6	12
11-Jun	-1	-6	-6	2	12	12	1	6	6	18
12-Jun	4	24	24	5	30	30	9	54	54	72
13-Jun	0	0	0	4	24	24	4	24	24	96
14-Jun	4	24	24	1	6	6	5	30	30	126
15-Jun	2	12	12	5	30	30	7	42	42	168
16-Jun	7	42	42	8	48	48	15	90	90	258
17-Jun	1	6	6	5	30	30	6	36	36	294
18-Jun	2	12	12	3	18	18	5	30	30	324
19-Jun	2	12	12	4	24	24	6	36	36	360
20-Jun	4	24	24	2	12	12	6	36	36	396
21-Jun	13	78	78	7	42	42	20	120	120	516
22-Jun	7	42	42	0	0	0	7	42	42	558
23-Jun	15	90	90	8	48	48	23	138	138	696
24-Jun	9	54	54	4	24	24	13	78	78	774
25-Jun	3	18	18	2	12	12	5	30	30	804
26-Jun	1	6	6	2	12	12	3	18	18	822
27-Jun	1	6	6	0	0	0	1	6	6	828
28-Jun	2	12	12	2	12	12	4	24	24	852
29-Jun	24	144	144	64	384	384	88	528	528	1,380
30-Jun	48	288	288	26	156	156	74	444	444	1,824
1-Jul	62	372	372	46	276	276	108	648	648	2,472
2-Jul	58	348	348	15	90	90	73	438	438	2,910
3-Jul	5	30	30	6	36	36	11	66	66	2,976
4-Jul	4	24	24	1	6	6	5	30	30	3,006
5-Jul	12	72	72	5	30	30	17	102	102	3,108
6-Jul	16	96	96	7	42	42	23	138	138	3,246
7-Jul	14	84	84	4	24	24	18	108	108	3,354
8-Jul	4	24	24	2	12	12	6	36	36	3,390
9-Jul	7	42	42	4	24	24	11	66	66	3,456
10-Jul	27	162	162	2	12	12	29	174	174	3,630
11-Jul	25	150	150	5	30	30	30	180	180	3,810
12-Jul	15	90	90	1	6	6	16	96	96	3,906
13-Jul	15	90	90	4	24	24	19	114	114	4,020
14-Jul	16	96	96	1	6	6	17	102	102	4,122
15-Jul	15	90	90	1	6	6	16	96	96	4,218
16-Jul	6	36	36	3	18	18	9	54	54	4,272
17-Jul	2	12	12	0	0	0	2	12	12	4,284

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	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
18-Jul	0	0	0	6	36	36	6	36	36	4,320
19-Jul	0	0	0	5	30	30	5	30	30	4,350
20-Jul	2	12	12	1	6	6	3	18	18	4,368
21-Jul	0	0	0	0	0	0	0	0	0	4,368
22-Jul	2	12	12	1	6	6	3	18	18	4,386
23-Jul	2	12	12	1	6	6	3	18	18	4,404
24-Jul	0	0	0	0	0	0	0	0	0	4,404
25-Jul	-1	-6	-6	0	0	0	-1	-6	-6	4,398
26-Jul	0	0	0	1	6	6	1	6	6	4,404
27-Jul	-1	-6	-6	-1	-6	-6	-2	-12	-12	4,392
28-Jul	5	30	30	2	12	12	7	42	42	4,434
29-Jul	-1	-6	-6	-1	-6	-6	-2	-12	-12	4,422
30-Jul	13	78	78	-1	-6	-6	12	72	72	4,494
31-Jul	10	60	60	-5	-30	-30	5	30	30	4,524
1-Aug	19	114	114	0	0	0	19	114	114	4,638
2-Aug	7	42	42	-3	-18	-18	4	24	24	4,662
3-Aug	2	12	12	3	18	18	5	30	30	4,692
4-Aug	3	18	18	2	12	12	5	30	30	4,722
5-Aug	5	30	30	3	18	18	8	48	48	4,770
6-Aug	3	18	18	9	54	54	12	72	72	4,842
7-Aug	0	0	0	4	24	24	4	24	24	4,866
8-Aug	4	24	24	-4	-24	-24	0	0	0	4,866
9-Aug[c]	9	54	54	-5	-30	-30	4	24	24	4,890
10-Aug	-1	-6	-6	-2	-12	-12	-3	-18	-18	4,872
11-Aug	-2	-12	-12	-2	-12	-12	-4	-24	-24	4,848
12-Aug	-3	-18	-18	-1	-6	-6	-4	-24	-24	4,824
13-Aug	-4	-24	-24	-1	-6	-6	-5	-30	-30	4,794
14-Aug	-2	-12	-12	-1	-6	-6	-3	-18	-18	4,776
15-Aug	0	0	0	-3	-18	-18	-3	-18	-18	4,758
16-Aug	-1	-6	-6	0	0	0	-1	-6	-6	4,752
17-Aug	0	0	0	0	0	0	0	0	0	4,752
TOTAL	534	3,204	3,204	281	1,686	1,686	815	4,890	4,890	

a Negative values represent downstream passage.

b Shading indicates days with interpolated values that are shown in bold italics when different from expanded count.

c Final day of counts used to estimate escapement.

Appendix B3.–Daily counts, daily expanded estimates and daily estimates that include interpolations for missed counts[a, b] of Chinook salmon at the Gulkana River tower site, 2004.

	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
28-May	0	0	0	0	0	0	0	0	0	0
29-May	0	0	0	0	0	0	0	0	0	0
30-May	0	0	0	0	0	0	0	0	0	0
31-May	0	0	0	0	0	0	0	0	0	0
1-Jun	0	0	0	0	0	0	0	0	0	0
2-Jun	0	0	0	0	0	0	0	0	0	0
3-Jun	0	0	0	0	0	0	0	0	0	0
4-Jun	0	0	0	0	0	0	0	0	0	0
5-Jun	0	0	0	0	0	0	0	0	0	0
6-Jun	5	30	30	4	24	24	9	54	54	54
7-Jun	2	12	12	17	102	102	19	114	114	168
8-Jun	0	0	0	7	42	42	7	42	42	210
9-Jun	1	6	6	0	0	0	1	6	6	216
10-Jun	0	0	***3***	0	0	***12***	0	0	***18***	***234***
11-Jun	0	0	0	1	6	***24***	1	6	***24***	***258***
12-Jun	0	0	0	1	6	6	1	6	6	***264***
13-Jun	0	0	0	0	0	0	0	0	0	***264***
14-Jun	0	0	0	1	6	6	1	6	6	***270***
15-Jun	0	0	0	4	24	24	4	24	24	***294***
16-Jun	3	18	18	4	24	24	7	42	42	***336***
17-Jun	1	6	6	7	42	42	8	48	48	***384***
18-Jun	3	18	18	4	24	24	7	42	42	***426***
19-Jun	2	12	12	27	162	162	29	174	174	***600***
20-Jun	6	36	36	56	336	336	62	372	372	***972***
21-Jun	7	42	42	50	300	300	57	342	342	***1,314***
22-Jun	5	30	30	55	330	330	60	360	360	***1,674***
23-Jun	7	42	42	46	276	276	53	318	318	***1,992***
24-Jun	0	0	0	39	234	234	39	234	234	***2,226***
25-Jun	0	0	0	65	390	390	65	390	390	***2,616***
26-Jun	0	0	0	54	324	324	54	324	324	***2,940***
27-Jun	2	12	12	87	522	522	89	534	534	***3,474***
28-Jun	3	18	18	57	342	342	60	360	360	***3,834***
29-Jun	0	0	0	9	54	54	9	54	54	***3,888***
30-Jun	1	6	6	8	48	48	9	54	54	***3,942***
1-Jul	0	0	0	0	0	0	0	0	0	***3,942***
2-Jul	0	0	0	-3	-18	-18	-3	-18	-18	***3,924***
3-Jul	3	18	18	5	30	30	8	48	48	***3,972***
4-Jul	-2	-12	-12	4	24	24	2	12	12	***3,984***
5-Jul	0	0	0	3	18	18	3	18	18	***4,002***
6-Jul	0	0	0	1	6	6	1	6	6	***4,008***
7-Jul	0	0	0	1	6	6	1	6	6	***4,014***
8-Jul	1	-6	-6	4	24	24	3	18	18	***4,032***
9-Jul	0	0	0	1	6	6	1	6	6	***4,038***
10-Jul	2	12	12	2	12	12	4	24	24	***4,062***
11-Jul	1	6	6	-1	-6	-6	0	0	0	***4,062***
12-Jul	0	0	0	-1	-6	-6	-1	-6	-6	***4,056***
13-Jul	0	0	0	12	72	72	12	72	72	***4,128***
14-Jul	2	12	12	11	66	66	13	78	78	***4,206***
15-Jul	-1	-6	-6	3	18	18	2	12	12	***4,218***
16-Jul	3	18	18	2	12	12	5	30	30	***4,248***
17-Jul	2	12	12	1	6	6	3	18	18	***4,266***

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	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
18-Jul	0	0	0	0	0	0	0	0	0	***4,266***
19-Jul	0	0	0	3	18	18	3	18	18	***4,284***
20-Jul	0	0	0	0	0	0	0	0	0	***4,284***
21-Jul	2	12	12	0	0	0	2	12	12	***4,296***
22-Jul	0	0	0	1	6	6	1	6	6	***4,302***
23-Jul	1	6	6	-1	-6	-6	0	0	0	***4,302***
24-Jul	0	0	0	0	0	0	0	0	0	***4,302***
25-Jul	-2	-12	-12	0	0	0	-2	-12	-12	***4,290***
26-Jul	0	0	0	-1	-6	-6	-1	-6	-6	***4,284***
27-Jul	-2	-12	-12	0	0	0	-2	-12	-12	***4,272***
28-Jul	0	0	0	0	0	0	0	0	0	***4,272***
29-Jul	1	6	6	1	6	6	2	12	12	***4,284***
30-Jul	8	48	48	5	30	30	13	78	78	***4,362***
31-Jul	5	30	30	6	36	36	11	66	66	***4,428***
1-Aug	6	36	36	4	24	24	10	60	60	***4,488***
2-Aug	3	18	18	6	36	36	9	54	54	***4,542***
3-Aug	11	66	66	6	36	36	17	102	102	***4,644***
4-Aug	9	54	54	3	18	18	12	72	72	***4,716***
5-Aug	0	0	0	-4	-24	-24	-4	-24	-24	***4,692***
6-Aug	1	6	6	0	0	0	1	6	6	***4,698***
7-Aug	1	6	6	2	12	12	3	18	18	***4,716***
8-Aug[c]	1	6	6	2	12	12	3	18	18	***4,734***
9-Aug	0	0	0	0	0	0	0	0	0	***4,734***
10-Aug	0	0	0	0	0	0	0	0	0	***4,734***
11-Aug	0	0	0	0	0	0	0	0	0	***4,734***
12-Aug	-1	-6	-6	-3	-18	-18	-4	-24	-24	***4,710***
13-Aug	0	0	0	-2	-12	-12	-2	-12	-12	***4,698***
14-Aug	0	0	0	0	0	0	0	0	0	***4,698***
TOTAL	102	612	615	681	4,086	4,116	783	4,698	4,734	

a Negative values represent downstream passage.

b Shading indicates days with interpolated values that are shown in bold italics when different from expanded count.

c Final day of counts used to estimate escapement.

APPENDIX C

Appendix C1.–Daily counts, daily expanded estimates and daily estimates that include interpolations for missed counts[a, b] of sockeye salmon at the Gulkana River tower site, 2002. These data are modified from those presented in Taras and Sarafin (2005).

	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
7-Jun	2	12	12	7	42	42	9	54	54	54
8-Jun	5	30	30	9	54	54	14	84	84	138
9-Jun	2	12	12	13	78	78	15	90	90	228
10-Jun	1	6	6	8	48	48	9	54	54	282
11-Jun	2	12	12	7	42	42	9	54	54	336
12-Jun	0	0	0	9	54	54	9	54	54	390
13-Jun	2	12	12	42	252	252	44	264	264	654
14-Jun	0	0	0	146	876	876	146	876	876	1,530
15-Jun	27	162	162	102	612	612	129	774	774	2,304
16-Jun	8	48	48	117	702	702	125	750	750	3,054
17-Jun	31	186	186	161	966	966	192	1,152	1,152	4,206
18-Jun	31	186	186	90	540	540	121	726	726	4,932
19-Jun	8	48	48	139	834	834	147	882	882	5,814
20-Jun	1	6	0	176	1,056	***1,170***	177	1,062	***1,170***	***6,984***
21-Jun	5	30	34	50	300	***942***	55	330	***976***	***7,960***
22-Jun	3	18	30	23	138	***960***	26	156	***990***	***8,950***
23-Jun	9	54	54	133	798	***822***	142	852	***876***	***9,826***
24-Jun	6	36	36	148	888	888	154	924	924	***10,750***
25-Jun	6	36	36	90	540	540	96	576	576	***11,326***
26-Jun	2	12	12	132	792	792	134	804	804	***12,130***
27-Jun	1	6	6	52	312	312	53	318	318	***12,448***
28-Jun	0	0	0	86	516	516	86	516	516	***12,964***
29-Jun	4	24	24	127	762	762	131	786	786	***13,750***
30-Jun	58	348	348	110	660	660	168	1,008	1,008	***14,758***
1-Jul	2	12	12	138	828	828	140	840	840	***15,598***
2-Jul	0	0	0	88	528	528	88	528	528	***16,126***
3-Jul	0	0	0	92	552	552	92	552	552	***16,678***
4-Jul	0	0	0	12	72	***84***	12	72	***84***	***16,762***
5-Jul	0	0	12	40	240	***234***	40	240	***246***	***17,008***
6-Jul	2	12	16	25	150	150	27	162	***166***	***17,174***
7-Jul	6	36	36	24	144	144	30	180	180	***17,354***
8-Jul	2	12	12	36	216	216	38	228	228	***17,582***
9-Jul	20	120	120	83	498	498	103	618	618	***18,200***
10-Jul	18	108	108	123	738	738	141	846	846	***19,046***
11-Jul	24	144	144	95	570	570	119	714	714	***19,760***
12-Jul	1	6	6	116	696	696	117	702	702	***20,462***
13-Jul	1	6	6	171	1,026	1,026	172	1,032	1,032	***21,494***
14-Jul	3	18	18	115	690	690	118	708	708	***22,202***
15-Jul	17	102	102	166	996	996	183	1,098	1,098	***23,300***
16-Jul	15	90	90	108	648	648	123	738	738	***24,038***
17-Jul	47	282	282	96	576	576	143	858	858	***24,896***
18-Jul	1	6	6	24	144	144	25	150	150	***25,046***
19-Jul	2	12	12	12	72	72	14	84	84	***25,130***
20-Jul	15	90	90	44	264	264	59	354	354	***25,484***
21-Jul	9	54	54	54	324	324	63	378	378	***25,862***
22-Jul	7	42	42	78	468	468	85	510	510	***26,372***
23-Jul	3	18	18	69	414	414	72	432	432	***26,804***
24-Jul	19	114	114	17	102	102	36	216	216	***27,020***
25-Jul	5	30	30	24	144	144	29	174	174	***27,194***
26-Jul	5	30	30	0	0	0	5	30	30	***27,224***
27-Jul	1	6	6	0	0	0	1	6	6	***27,230***

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	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
28-Jul	1	6	6	5	30	30	6	36	36	***27,266***
29-Jul	-2	-12	-12	0	0	0	-2	-12	-12	***27,254***
30-Jul	1	6	6	12	72	72	13	78	78	***27,332***
31-Jul	1	6	6	6	36	36	7	42	42	***27,374***
1-Aug	11	66	66	14	84	84	25	150	150	***27,524***
2-Aug	14	84	84	70	420	420	84	504	504	***28,028***
3-Aug	29	174	174	42	252	252	71	426	426	***28,454***
4-Aug	9	54	54	35	210	210	44	264	264	***28,718***
5-Aug	15	90	90	37	222	222	52	312	312	***29,030***
6-Aug	7	42	42	14	84	84	21	126	126	***29,156***
7-Aug	13	78	78	58	348	348	71	426	426	***29,582***
8-Aug	14	84	84	38	228	228	52	312	312	***29,894***
9-Aug	12	72	72	16	96	96	28	168	168	***30,062***
TOTAL	564	3,384	3,410	4,174	25,044	26,652	4,738	28,428	30,062	

[a] Negative values represent downstream passage.

[b] Shading indicates days with interpolated values that are shown in bold italics when different from expanded count.

Appendix C2.–Daily counts, daily expanded estimates and daily estimates that include interpolations for missed counts[a, b] of sockeye salmon at the Gulkana River tower site, 2003.

	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
28-May	0	0	0	0	0	0	0	0	0	0
29-May	0	0	0	0	0	0	0	0	0	0
30-May	0	0	0	0	0	0	0	0	0	0
31-May	0	0	0	0	0	0	0	0	0	0
1-Jun	0	0	0	0	0	0	0	0	0	0
2-Jun	0	0	0	0	0	0	0	0	0	0
3-Jun	0	0	0	0	0	0	0	0	0	0
4-Jun	0	0	0	0	0	0	0	0	0	0
5-Jun	0	0	0	-1	-6	-6	-1	-6	-6	-6
6-Jun	6	36	36	2	12	12	8	48	48	48
7-Jun	2	12	12	2	12	12	4	24	24	72
8-Jun	7	42	42	1	6	6	8	48	48	120
9-Jun	21	126	126	8	48	48	29	174	174	294
10-Jun	13	78	78	5	30	30	18	108	108	402
11-Jun	42	252	252	15	90	90	57	342	342	744
12-Jun	11	66	66	15	90	90	26	156	156	900
13-Jun	12	72	72	22	132	132	34	204	204	1,104
14-Jun	11	66	66	6	36	36	17	102	102	1,206
15-Jun	9	54	54	22	132	132	31	186	186	1,392
16-Jun	13	78	78	45	270	270	58	348	348	1,740
17-Jun	0	0	0	32	192	192	32	192	192	1,932
18-Jun	23	138	138	13	78	78	36	216	216	2,148
19-Jun	2	12	12	6	36	36	8	48	48	2,196
20-Jun	5	30	30	13	78	78	18	108	108	2,304
21-Jun	9	54	54	19	114	114	28	168	168	2,472
22-Jun	9	54	54	12	72	72	21	126	126	2,598
23-Jun	34	204	204	29	174	174	63	378	378	2,976
24-Jun	23	138	138	16	96	96	39	234	234	3,210
25-Jun	13	78	78	18	108	108	31	186	186	3,396
26-Jun	15	90	90	28	168	168	43	258	258	3,654
27-Jun	10	60	60	6	36	36	16	96	96	3,750
28-Jun	31	186	186	20	120	120	51	306	306	4,056
29-Jun	16	96	96	38	228	228	54	324	324	4,380
30-Jun	57	342	342	39	234	234	96	576	576	4,956
1-Jul	86	516	516	27	162	162	113	678	678	5,634
2-Jul	50	300	300	45	270	270	95	570	570	6,204
3-Jul	43	258	258	30	180	180	73	438	438	6,642
4-Jul	35	210	210	50	300	***306***	85	510	***516***	***7,158***
5-Jul	80	480	480	56	336	336	136	816	816	***7,974***
6-Jul	52	312	312	26	156	156	78	468	468	***8,442***
7-Jul	92	552	552	35	210	210	127	762	762	***9,204***
8-Jul	55	330	330	8	48	48	63	378	378	***9,582***
9-Jul	48	288	288	37	222	222	85	510	510	***10,092***
10-Jul	29	174	174	38	228	228	67	402	402	***10,494***
11-Jul	52	312	312	25	150	150	77	462	462	***10,956***
12-Jul	70	420	420	22	132	132	92	552	552	***11,508***
13-Jul	53	318	318	10	60	60	63	378	378	***11,886***
14-Jul	80	480	480	21	126	126	101	606	606	***12,492***
15-Jul	21	126	126	16	96	96	37	222	222	***12,714***
16-Jul	1	6	6	25	150	150	26	156	156	***12,870***
17-Jul	6	36	36	13	78	78	19	114	114	***12,984***

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	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
18-Jul	5	30	30	6	36	36	11	66	66	***13,050***
19-Jul	16	96	96	22	132	132	38	228	228	***13,278***
20-Jul	25	150	150	13	78	78	38	228	228	***13,506***
21-Jul	9	54	54	11	66	66	20	120	120	***13,626***
22-Jul	12	72	72	18	108	108	30	180	180	***13,806***
23-Jul	2	12	12	3	18	18	5	30	30	***13,836***
24-Jul	6	36	36	8	48	48	14	84	84	***13,920***
25-Jul	5	30	30	6	36	36	11	66	66	***13,986***
26-Jul	5	30	30	1	6	6	6	36	36	***14,022***
27-Jul	1	6	6	4	24	24	5	30	30	***14,052***
28-Jul	0	0	0	5	30	30	5	30	30	***14,082***
29-Jul	6	36	36	1	6	6	7	42	42	***14,124***
30-Jul	1	6	6	3	18	18	4	24	24	***14,148***
31-Jul	8	48	48	1	6	6	9	54	54	***14,202***
1-Aug	2	12	12	1	6	6	3	18	18	***14,220***
2-Aug	1	6	6	0	0	0	1	6	6	***14,226***
3-Aug	4	24	24	3	18	18	7	42	42	***14,268***
4-Aug	2	12	12	0	0	0	2	12	12	***14,280***
5-Aug	3	18	18	0	0	0	3	18	18	***14,298***
6-Aug	4	24	24	6	36	36	10	60	60	***14,358***
7-Aug	10	60	60	-4	-24	-24	6	36	36	***14,394***
8-Aug	10	60	60	10	60	60	20	120	120	***14,514***
9-Aug	20	120	120	15	90	90	35	210	210	***14,724***
10-Aug	36	216	216	14	84	84	50	300	300	***15,024***
11-Aug	38	228	228	31	186	186	69	414	414	***15,438***
12-Aug	53	318	318	21	126	126	74	444	444	***15,882***
13-Aug	46	276	276	-2	-12	-12	44	264	264	***16,146***
14-Aug	66	396	396	20	120	120	86	516	516	***16,662***
15-Aug	83	498	498	37	222	222	120	720	720	***17,382***
16-Aug	66	396	396	73	438	438	139	834	834	***18,216***
17-Aug	81	486	486	83	498	498	164	984	984	***19,200***
18-Aug	45	270	270	31	186	186	76	456	456	***19,656***
TOTAL	1,918	11,508	11,508	1,357	8,142	8,148	3,275	19,650	19,656	

a Negative values represent downstream passage.

b Shading indicates days with interpolated values that are shown in bold italics when different from expanded count.

Appendix C3.–Daily counts, daily expanded estimates and daily estimates that include interpolations for missed counts[a, b] of sockeye salmon at the Gulkana River tower site, 2004.

	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
28-May	0	0	0	0	0	0	0	0	0	0
29-May	0	0	0	0	0	0	0	0	0	0
30-May	0	0	0	0	0	0	0	0	0	0
31-May	0	0	0	0	0	0	0	0	0	0
1-Jun	0	0	0	0	0	0	0	0	0	0
2-Jun	0	0	0	0	0	0	0	0	0	0
3-Jun	0	0	0	0	0	0	0	0	0	0
4-Jun	0	0	0	0	0	0	0	0	0	0
5-Jun	1	6	***15***	3	18	***45***	4	24	***60***	***60***
6-Jun	5	30	30	15	90	90	20	120	120	***180***
7-Jun	10	60	60	57	342	342	67	402	402	***582***
8-Jun	4	24	24	55	330	330	59	354	354	***936***
9-Jun	1	6	***-6***	27	162	***168***	28	168	***162***	***1,098***
10-Jun	0	0	***27***	0	0	***84***	0	0	***111***	***1,209***
11-Jun	3	18	***60***	0	0	0	3	18	***60***	***1,269***
12-Jun	2	12	24	2	12	12	4	24	36	***1,305***
13-Jun	2	12	12	7	42	42	9	54	54	***1,359***
14-Jun	3	18	18	61	366	366	64	384	384	***1,743***
15-Jun	2	12	12	52	312	312	54	324	324	***2,067***
16-Jun	2	12	12	32	192	192	34	204	204	***2,271***
17-Jun	4	24	24	64	384	384	68	408	408	***2,679***
18-Jun	3	18	18	39	234	234	42	252	252	***2,931***
19-Jun	4	24	24	64	384	384	68	408	408	***3,339***
20-Jun	2	12	12	86	516	516	88	528	528	***3,867***
21-Jun	5	30	30	81	486	486	86	516	516	***4,383***
22-Jun	5	30	30	69	414	414	74	444	444	***4,827***
23-Jun	2	12	12	66	396	396	68	408	408	***5,235***
24-Jun	2	12	12	47	282	282	49	294	294	***5,529***
25-Jun	3	18	18	58	348	348	61	366	366	***5,895***
26-Jun	0	0	0	94	564	564	94	564	564	***6,459***
27-Jun	-1	-6	-6	56	336	336	55	330	330	***6,789***
28-Jun	0	0	0	75	450	450	75	450	450	***7,239***
29-Jun	-2	-12	-12	17	102	102	15	90	90	***7,329***
30-Jun	0	0	0	11	66	66	11	66	66	***7,395***
1-Jul	4	24	24	4	24	24	8	48	48	***7,443***
2-Jul	0	0	0	14	84	84	14	84	84	***7,527***
3-Jul	1	6	6	25	150	150	26	156	156	***7,683***
4-Jul	2	12	12	16	96	96	18	108	108	***7,791***
5-Jul	0	0	0	24	144	144	24	144	144	***7,935***
6-Jul	0	0	0	17	102	102	17	102	102	***8,037***
7-Jul	1	6	6	38	228	228	39	234	234	***8,271***
8-Jul	5	30	30	30	180	180	35	210	210	***8,481***
9-Jul	0	0	0	29	174	174	29	174	174	***8,655***
10-Jul	0	0	0	12	72	72	12	72	72	***8,727***
11-Jul	-1	-6	-6	8	48	48	7	42	42	***8,769***
12-Jul	1	6	6	12	72	72	13	78	78	***8,847***
13-Jul	0	0	0	10	60	60	10	60	60	***8,907***
14-Jul	0	0	0	8	48	48	8	48	48	***8,955***
15-Jul	0	0	0	7	42	42	7	42	42	***8,997***
16-Jul	0	0	0	29	174	174	29	174	174	***9,171***
17-Jul	0	0	0	15	90	90	15	90	90	***9,261***

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	East Channel			West Channel			Total			Season
Day	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Daily Count	Expanded Count	Interpolations Included	Cumulative Estimate
18-Jul	2	12	12	26	156	156	28	168	168	***9,429***
19-Jul	10	60	60	42	252	252	52	312	312	***9,741***
20-Jul	1	6	6	41	246	246	42	252	252	***9,993***
21-Jul	3	18	18	84	504	504	87	522	522	***10,515***
22-Jul	0	0	0	113	678	678	113	678	678	***11,193***
23-Jul	0	0	0	64	384	384	64	384	384	***11,577***
24-Jul	1	6	6	76	456	456	77	462	462	***12,039***
25-Jul	1	6	6	66	396	396	67	402	402	***12,441***
26-Jul	1	6	6	22	132	132	23	138	138	***12,579***
27-Jul	0	0	0	32	192	192	32	192	192	***12,771***
28-Jul	3	18	18	30	180	180	33	198	198	***12,969***
29-Jul	3	18	18	22	132	132	25	150	150	***13,119***
30-Jul	13	78	78	27	162	162	40	240	240	***13,359***
31-Jul	7	42	42	33	198	198	40	240	240	***13,599***
1-Aug	9	54	54	29	174	174	38	228	228	***13,827***
2-Aug	2	12	12	36	216	216	38	228	228	***14,055***
3-Aug	12	72	72	35	210	210	47	282	282	***14,337***
4-Aug	5	30	30	13	78	78	18	108	108	***14,445***
5-Aug	5	30	30	4	24	24	9	54	54	***14,499***
6-Aug	0	0	0	7	42	42	7	42	42	***14,541***
7-Aug	5	30	30	15	90	90	20	120	120	***14,661***
8-Aug	1	6	6	18	108	108	19	114	114	***14,775***
9-Aug	4	24	24	19	114	114	23	138	138	***14,913***
10-Aug	3	18	18	12	72	72	15	90	90	***15,003***
11-Aug	2	12	12	15	90	90	17	102	102	***15,105***
12-Aug	3	18	18	3	18	18	6	36	36	***15,141***
13-Aug	0	0	0	15	90	90	15	90	90	***15,231***
14-Aug	2	36	4	6	108	12	8	144	16	***15,247***
TOTAL	173	1,062	1,108	2,341	14,118	14,139	2,514	15,180	15,247	

[a] Negative values represent downstream passage.

[b] Shading indicates days with interpolated values that are shown in bold italics when different from expanded count.